SCOTTISH SCHOOLS SCIENCE

EQUIPMENT RESEARCH

CENTRE

Bulletin No. 62. April, 1973.

Contents

Introduction

By the time that this Bulletin appears in print, Value Added Tax at a standard rate of 10% will have been introduced, and purchase tax and selective employment tax will have disappeared. How will this affect the science teacher ordering apparatus? Firstly, on those items which carried purchase tax in excess of 10%, the price may now be less. Since scientific equipment does not carry purchase tax, this relief will be limited to items in the science department's budget which are manufactured for domestic use, i.e. practically everything bought with petty cash, and larger items such as refrigerators.

Now, the cost of all equipment purchased by the department will be increased in the first instance by 10%, and teachers making out requisitions may have to allow for this. But "Under section 15 (1) of the Finance Act 1972 a special scheme will operate under which any VAT which is invoiced and charged to local authorities and similar bodies by suppliers of goods and services which are <u>not for the purpose of a business activity</u> carried on by the local authority or similar body, will be refunded by Customs and Excise".* Thus although VAT will be paid on purchases of science equipment, the authority can recover this tax regularly. How these arrangements are put into practice may vary between different authorities; some may instruct their schools to ignore VAT when costing their requisitions, some may keep their ceiling total inclusive of VAT, and use the recovered tax to fund a supplementary requisition. It is worth pointing out that these arrangements are similar to those under which LEA could recover purchase tax under the old system, the only difference being in the very much larger amount involved under VAT. The impact of VAT will be felt most heavily in the private schools, which cannot claim to be "not for the purpose of a business activity". They should, however, benefit from the disappearance of SET.

*Notice No. 749; VAT, Local Authorities and Similar Bodies, Her Majesty's Customs and Excise, free.

Opinion

<u>The Australian Science Education Project</u>, called ASEP for short, or because it fits the current fashion for such acronyms, is based on a series of units, only some of which are interlinked, so that the use of the units is to some extent optional. Within the units themselves, there is a common core which all students studying the unit cover, and a series of options which give a wide

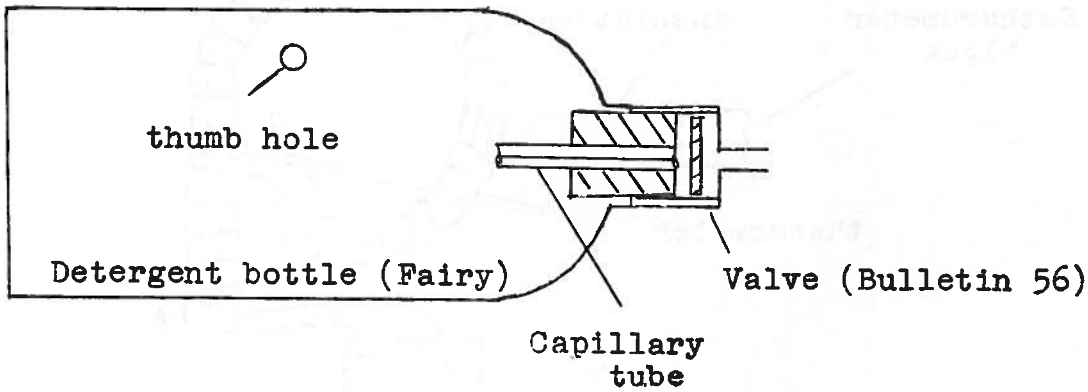
choice to teachers and perhaps students to follow their own bent. The contents of some of the units can be readily imagined from their titles: water, soils, energy and change, a model for matter. Others, such as 'little boxes', and 'systems' can be more intriguing. Little boxes is a study of homes and buildings; why we need them, how we arrange them. Systems is more intriguing still, since it is a study of black boxes, or what many of us understand by the concept of the black box, as the term is often pejoratively used in U.K. educational circles. In other words, the unit attempts to assess the black box, a collection of interacting parts, in terms of what it does rather than how it works.

The concept of a system as ASEP interprets it, is very wide indeed, and cannot be appreciated without extensive quotation from the ASEP material. Here I must be careful, since the copy-right informs me that no part of the materials may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, or otherwise without the prior written permission of the project director. I therefore crave his indulgence to quote here that a system "is anything that can receive inputs, do something with them and then give something out. A system is any group of things that have an effect on each other", or again "something that transforms an input to an output". Examples of ASEP systems give more food for thought; apply the touchstone 'what is the input, the output, the purpose' to each of the following examples: a telephone, a kindergarten, a spanner, pot of glue, television set. If the pot of glue puzzles you, you are not alone. It has a purpose, it stores glue, but how does it transform the input to the output? Presumably from one large dollop to small quantities. Maybe we can better understand what they mean by a system if we attempt a classification, i.e. if we can identify a non-system. We are given little guidance here, but it is suggested that a 'nothing' system (Australian for non-system?) might be two magnets stored in repulsion so that one supports the other against gravity. Compared with the pot of glue, this also has an input and an output, viz. magnets, and a purpose in that it stores the magnets, and a transformation in that the output magnets will be weaker than when they went in. So if this is a non-system, perhaps the purposes of a system have to be well-intentioned, and the transformations beneficial. Can we therefore reach a definition of a system (for our own satisfaction only, since it is now the way of the world to frown on definitions) as a collection of parts which does not have its maximum possible entropy?

But there are other systems, or what we would like to call systems, which do not fit neatly into these classifications. Biology is full of them. A nest of rabbits has an input of father and mother rabbit, an output which has been a music-hall joke for years, but has it a purpose? In any biological system, can we identify a purpose, or, more metaphysically, a purposing being?

Chemistry Notes

In the chemistry syllabus there are instances where it is necessary to push air over a substance in a combustion tube, e.g. over heated metal sulphide to show production of sulphur dioxide. The diagram below shows one way of obtaining such an air flow.



The capillary tubing ensures a slow stream of air when the hole is closed by the thumb and the detergent bottle pressed. Without this controlled flow of air there would be the danger of quick pressing giving a surge of air sufficient to blow any powder, etc. out of the reaction tube.

The one way valve is essential only when the gaseous products are being collected by the gas collecting apparatus described in Bulletin 47. There is one important difference in this gas collector, in that the glass bead in the inlet tube is omitted. If a non-return valve were not fitted, then the weight of the test-tube in the collector would create enough pressure to move the gases into the detergent bottle each time it was released.

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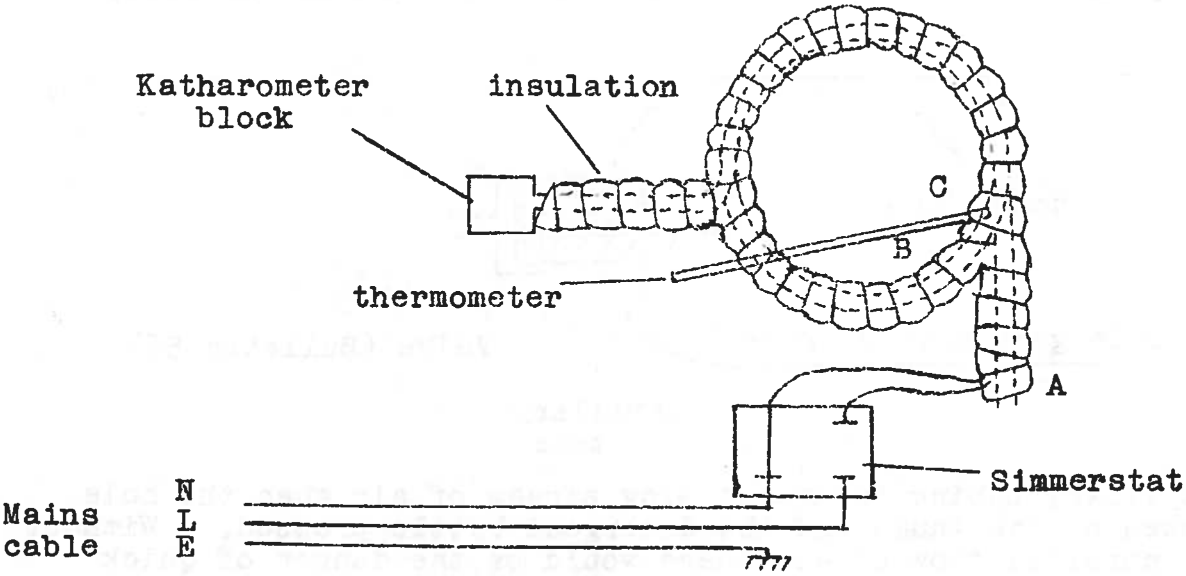
A number of schools are using the Gallenkamp Junior Gas Chromatograph, catalogue number CL-910, a good instrument but expensive at £98. The instrument is designed for use at ambient temperature and works very satisfactorily for compounds which are gaseous or have low boiling points. The versatility of the instrument is greatly increased by having a means of heating the column and suggestions for doing this are given below. We have had the co-operation of the Gallenkamp representative in carrying out the modifications and tests.

The heating tape is from Gallenkamp, catalogue number HE152, length 914mm, price £5.55. The temperature control is by an energy regulator (Simmerstat) catalogue number E.C.910, price £3.30. The latter has a scale reading from 0 to 100.

The tape is first stretched and then wound on the column as shown in figure 1, starting at A and finishing at B. The part of the column still exposed and leading to the katharometer should be insulated with glass wool or asbestos tape. Even winding and complete covering of the column by tape is essential to ensure uniform temperature. The regulator is fixed on the front of the case near the injection point, and three-core mains cable is brought to it through a terminal block bolted on the inside of the case at one side.



The connections on the regulator should be well insulated by tape or protected by a perforated plastic box placed over it.

The perspex top should be kept off when the column is being heated. For measuring the temperature of the column a mercury thermometer reading to at least 250°C is required. The column is exposed for a length of about 25mm at any point away from the ends and the bulb of the thermometer placed there. The thermometer bulb is held against the column by metal foil e.g. copper, wrapped round the bulb and column. Glass wool is then wrapped round the metal foil to prevent heat loss from the column and so give a reasonably accurate reading of the column temperature. For convenience the thermometer was placed horizontally across the column with the bulb at position C as shown in the diagram.

Satisfactory temperature control is obtained by using the energy regulator. At maximum setting of 100 a steady temperature of 220°C was reached in 15 minutes. It is important to note that the energy regulator is not a thermostat. For different settings the current is simply switched off and on for different periods of time. Thus for a particular setting the column will reach a steady temperature when the electrical energy input balances the heat energy dissipated by the column and heating tape. The steady temperature reached will obviously depend on the ambient temperature and therefore in order to keep this steady, the temperature of the laboratory should be reasonably constant.

It is advisable to calibrate the scale for temperature; the table below shows the column temperatures obtained against various scale settings of the control.

Scale Readings	0	10	20	30	40	50	60	70	80 to 100
Temperature °C	35	57	75	97	118	144	158	175	227

Once the calibration is available then the column is heated to the required temperature by setting the dial to the appropriate reading. About 30 minutes is required for steady temperature to be reached. One might think that it would be quicker to set the dial to maximum and then to turn down to the required temperature but due to the insulating effect of the tape the temperature decrease is very slow. To illustrate this we found the time starting from cold at setting 20 to reach 75°C was 30 minutes, but setting the dial to maximum until the temperature was steady at 222°C then setting to 20, the temperature had not fallen below 100°C after 5½ hours.

The time of elution of a substance in gas chromatography depends on carrier gas used, flow rate, nature and concentration of stationary phase and the temperature. The big advantage of a heated column is that retention time for compounds is decreased; in fact if the temperature is raised above a certain level there will be no retention at all in the column. If we consider the case where a liquid of too high a boiling point has been injected into a column at ambient temperature it will be found that there might be almost complete retention of the compound in the column. In such a case quick elution could be obtained by heating the column whereas if no heating of the column was possible prolonged flow of carrier gas would be required or even emptying of the column and re-filling. A good illustration of the effect of temperature on retention time was obtained by injecting 10µl of chlorobenzene, B.P. 130°C, into the column at room temperature. The column used in the CL910 model is 120cm long and contains general purpose silicone on celite 80-120 mesh. The flow of nitrogen as carrier was $40cm^3$/minute and column temperature 22°C. After 5 minutes the katharometer detected a small amount of chlorobenzene and this continued for 55 minutes, but the heating of the column was started then and during the next 9 minutes as the temperature rose to 180°C the chlorobenzene was almost completely eluted. A retention time of 3 minutes for chlorobenzene was observed when the column was operated at 210°C.

A further illustration is the separation of di-, tri-, and tetrachloromethane. With the column at 22°C, a flow rate of $40cm^3$/min and 10µl of mixture injected, separation was obtained but at long retention times of 7, 16 and 20.5 minutes. Using a column temperature of 70°C the retention times were 1, 2 and 2.5 minutes.

* * * * *

We have a note from an English inspector of two accidents which occurred to him when he was teaching. The first concerns the preparation of oxygen from potassium chlorate, an experiment which we hope is never carried out now, since there are equally suitable and much safer methods of preparing the gas. His letter should speak for itself. "A laboratory assistant had equipped a stout flask with a charred cork and this was in use for preparing oxygen from potassium chlorate. A small piece of cork broke off and dropped in the molten potassium chlorate causing an explosion which discharged the contents of the flask, at a temperature of some 350°C, over my left hand".

"A second incident occurred when an over zealous laboratory assistant half packed a silica tube with magnesium powder instead of magnesium ribbon over woolly asbestos. On heating the area of the tube containing the magnesium when steam was generated from the asbestos, there was a rocket-like sheet of flame from the upper end of the tube, discharging the cork and delivery tube. Fortunately the only damage was to glassware; the silica tube did not break".

It is perhaps worth noting that in the second experiment we would now recommend that asbestos be replaced by Rocksil, and that in the Teacher's Guide to Chemistry Takes Shape, Book 1, p.43, Johnston and Morrison recommend that the experiment be demonstrated with no delivery tube.

* * * * *

A Scottish school has written us this note on what could have been a serious accident.

"We carried out the usual experiments on metal oxides using charcoal blocks and blowpipes. The reductions were successful and the blocks were allowed to cool on an asbestos sheet, on a side bench free from draughts. After approximately one hour's cooling the blocks had increased in heat and had crumbled to a fine whitish - yellow ash. The heat evolved was so intense that the bench was severely charred.

The charcoal blocks were newly purchased (Sept 72). I have used charcoal blocks on many previous occasions but have not, until today, experienced (a) such intense heat evolved while cooling and (b) the charcoal decomposing to a fine ash".

Biology Notes

On the subject of anaerobic respiration, Section III (4) (a) is quite specific that 'yeast and the production of carbon dioxide and heat' should be studied. Probably the commonest way of investigating these phenomena has been by placing yeast and glucose solution in a vacuum flask, fitted with a rubber bung holding a mercury thermometer and glass delivery tube, the other end of which dips into a tube of bicarbonate indicator. However, the electronic thermometer described in Bulletin 55, together with a 'Medicon' probe (Bulletin 57), provides such a sensitive heat detector that a vacuum flask is not needed. Instead, the arrangement shown below can be used, several pairs of tubes being set up to cater for the main experiment and the various controls - boiled yeast, no glucose, etc. It will be appreciated that, as well as being cheaper, the arrangement allows the pupils to see all that is happening.

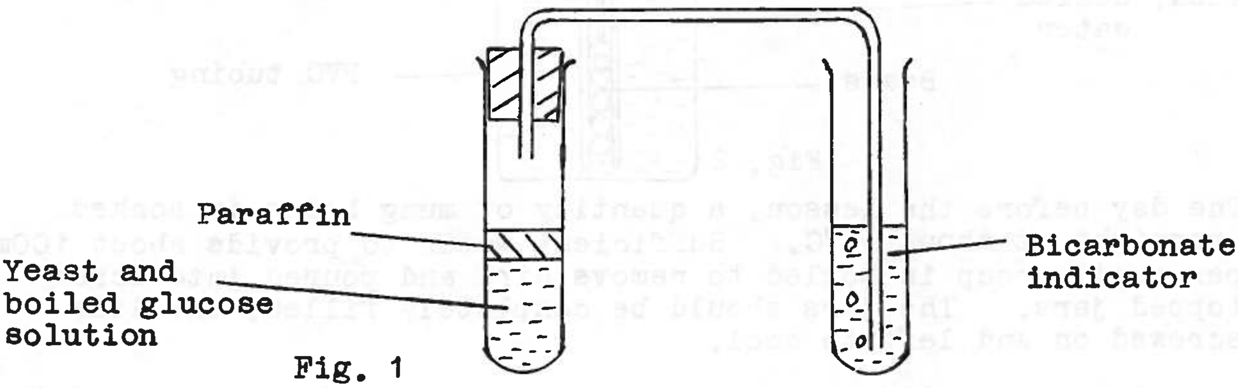


Fig. 1

The probe is inserted into the liquid in one of the left-hand tubes at the start of the experiment, and the zero control knob used to bring the meter pointer to zero. The probe can then be inserted into each of the other tubes in turn, to confirm that they have all started at the same temperature. After the indicator has turned yellow in the main experiment the probe is inserted into each of the control tubes in turn to confirm that there has been no temperature rise, and then into the yeast/glucose suspension when there should be a massive deflection of the meter pointer. The experiment is better carried out with a demonstration meter plugged into the thermometer outlet. The White Electrical INDC, Weir Electrical 9/UNI and Unilab 23cm demonstration meters are all suitable for this purpose.

Another well known method of demonstrating anaerobic respiration is to suspend several germinating pea seeds over mercury in an inverted test tube. A modification of this uses a gas burette in place of the test tube, so that at the end of the experiment a sample of the accumulated gas may be withdrawn by syringe for analysis. The arrangement shown in diagram 2 uses the gas analysis tube first described in Bulletin 50, and we believe it to be both simpler than the other arrangements, and also more suitable for pupil work since it does not involve mercury.

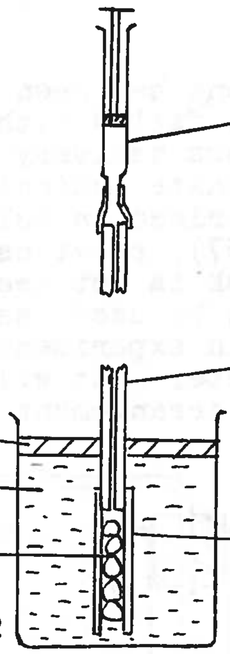


Fig. 2

The day before the lesson, a quantity of mung beans is soaked overnight at about 37°C. Sufficient water to provide about 100ml per pupil group is boiled to remove air, and poured into screw-topped jars. The jars should be completely filled, the lids screwed on and left to cool.

For the experiment itself the pupils pour the boiled water into a beaker and immediately cover with liquid paraffin to exclude air. The analysis tube is laid on the bench and 4-5 beans are pushed into the short length of PVC tubing. The syringe plunger is fully withdrawn and the tube fixed in a clamp as shown in Fig. 2, with the end of the PVC tubing near enough the bottom of the beaker to prevent the beans being expelled when the plunger is pushed home, which is done to expel any paraffin which may be in the PVC tubing. Then the syringe plunger is withdrawn to fill the PVC tubing and about half the analysis tube with water.

The apparatus is then left set up for gas to accumulate in the PVC tubing. We have found that the tubing filled with gas if left in a warm place in about 12 hours. A 10cm length of gas is drawn into the analysis tube, the PVC tubing is flicked off and a water seal drawn in. The gas is then analysed with hydroxide solution and pyrogallol as described in Bulletin 60. In six trials we found an average composition of over 80% carbon dioxide, the rest being nitrogen.

Physics Notes

A flip flop using relays may seem something of an anachromism in these days of dual in-line integrated circuit chips. However, there may be pupils, perhaps even some teachers, who feel more confident if they know what is taking place. In the bad old days every child studied the electric bell circuit, and perhaps because of this it has been dropped from Integrated Science, which seems a pity because it is a good example of a system with feed back. But if a pupil has examined the bell or buzzer circuit, e.g. during the Electrics topic in the Second Cycle of Integrated Science, and has come to realise that it is a relay with a single break contact, then he is in a position to try something more ambitious. The problem can be posed - 'Can you wire two relays so that they switch each other off and on continuously'?

The solution is to cross-couple the relays as in the electronic flip flop; each is wired to the supply through a contact on the other relay, and one should be a make and one a break contact. The repetition frequency of the flip flop is determined by the time taken for the relay contacts to engage, and is to some extent affected by the supply voltage, in that a higher voltage causes the relay armature to move more rapidly. One can also reduce the frequency by using what the G.P.O. call slugged relays, which have a hollow metal cylinder covering the core at one end, and which is in fact a shorted turn, thus producing damping. Amongst our surplus equipment we have both types of relay suitable for constructing flip flops; unslugged to operate off a 6V supply and slugged off 18V. Both types cost 5p each.

* * * * *

A suggestion from Craigmount School, Edinburgh, has caused us to take a new look at an old experiment, Oersted's rotating wire. In this, a magnet is cemented in the centre of a shallow dish such as a petrie dish so that the magnetic axis is vertical. A copper wire is suspended some 10-15cm above it by being looped through a similar wire which is stationary. The bottom end of the suspended wire dips into mercury in the dish and when current is passed down the wire into the mercury it rotates around the magnet. The suggestion was that we should try solutions of electrolytes in preference to mercury, which has disadvantages other than price. We found that this worked, the greater resistance of the electrolyte making it necessary only to use a higher voltage, which is readily obtainable from the usual low voltage power supply. We also found it necessary to varnish the magnet to make it non-conducting, as it otherwise provided a low resistance path for the current when the hanging wire touched it. The table below shows the values at which we succeeded in getting rotation of the wire. In the column headed concentration is given the quantity of solid dissolved in 100ml of water to form the electrolyte.

Substance	Concentration g	Current A	Voltage V
Mercury	-	0.8	2
Magnesium nitrate	7.5	0.2	10
Copper sulphate	13.5	0.12	20
Sodium hydroxide	7.5	0.14	4

We have been less successful with Barlow's wheel, which is probably due to the fact that more current than the LV power unit can supply is needed to overcome the increased friction at the pivots.

Trade News

The Young Students' Laboratory Guide is a small handbook giving advice on how to behave in a science laboratory to ensure the student's own safety while carrying out experiments. The guide costs 15p from Spectrum Books.

Sauter balances, which were marketed in the U.K. by Shandon Instruments, are now being sold by Industrial Scales. The Scottish agent for these balances is John White and Sons.

Photographic paper, single weight glossy, can be bought in bulk from A.W. Young in the following sizes; cost includes postage.

10"	x	8"	50 sheets	£1
	"		100 sheets	1.52
$6\frac{1}{2}$"	x	$8\frac{1}{2}$"	50 sheets	0.70
	"		100 sheets	1.25
$4\frac{1}{2}$"	x	$6\frac{1}{2}$"	100 sheets	0.71
$3\frac{1}{2}$"	x	$5\frac{1}{2}$"	100 sheets	0.57
$4\frac{1}{2}$"	x	$3\frac{1}{2}$"	100 sheets	0.47
10"	x	50ft	roll	1.05
10"	x	100ft	roll	1.75

The firm of H.F. Applegate which is marketing the remaining stocks of W.B. Nicolson apparatus has changed its address to that given in the address list to this bulletin.

"Rough service" electric light bulbs, obtainable from wholesale electricians, and manufactured for use on building sites etc., will last longer where a bulb is required to burn in a horizontal position, such as in locust cages. Costs we have had quoted, per 25 bulbs, are: 25, 40 and 60W, all £3.33; 100W, £4.59.

Schools ordering bunsen burners for use on liquid petroleum gas (variously called propane, butane or calor gas) from Griffin and George should ask for them under catalogue number S16-957. This number is not listed in the 1972 catalogue, but the burner is the Flamefast version, reported on in Bulletin 42, with a jet making it suitable for LPG. The Flamefast semi-micro burner, S17-066 in the Griffin catalogue is for use with natural gas, but on request to Flamefast, not Griffin and George, jets for use on LPG can be supplied.

Bulletin Supplement

Below is a summary of test reports on a selection of colorimeters; teachers should refer to Bulletin 52 for an account of the procedures under which these were tested. Individual reports on these instruments can be borrowed by writing to the Director. The classifications used are:

A - most suitable for school use; B - satisfactory for school use; C - unsatisfactory.

Model	Educon	S19-810	Foxall	C065
Manufacturer	Decon Laboratories	Griffin and George	Open University	WPA
Price	£20	£16.50	£25.50	£22
Filters included	8	None	None	8
Meter Scales	0-2mA	Not included *	%age transmission	%age transmission optical density
Sensitivity 1 div=	0.1mA	-	2%	2% 0.05**
Detector cell	Photo-conductive	Photo-voltaic	Photo-voltaic	Photo-conductive
Light source	6V MES	2.5V MES	4.8V MES	6.5V MES
Light supply	Dry Battery	Lead acid+	Battery stabilised	Mains stabilised
Sensitivity control	Potentiometer	Slit aperture	Slit aperture and triple range pre-set	Dual range pre-set
Performance	Unsatisfactory	Satisfactory	Satisfactory	Satisfactory
Assessment	C++	B	B	A

Notes
* A 50μA meter is required.
** Logarithmic scale, with step 0.05 or less down to 90% absorption.
\+ 2V accumulator recommended by the supplier.
++ Unsatisfactory performance because it is dependent on battery voltage.

S.S.S.E.R.C., 103 Broughton Street, Edinburgh, EH1 3RZ.
Tel. 031-556 2184

H.F. Applegate Ltd., 79 St. Neots Road, Harold Hill, Romford, Essex.

A.S.E.P., 11 Glenbervie Road, Toorak, Victoria, Australia, 3142.

Decon Laboratories Ltd., Ellen Street, Portslade, Brighton, BN4 1EQ.

Flamefast Engineering Ltd., Pendlebury Industrial Estate, Bridge Street, Swinton, Manchester M27 1FJ.

A. Gallenkamp and Co. Ltd., Portrack Lane, Stockton-on-Tees, Teeside, TS18 2PT.

Griffin and George Ltd., Braeview Place, Nerston, East Kilbride.

Industrial Scales Ltd., Orpington, Kent.

Open University, Walton Hall, Walton, Bletchley, Bucks.

Shandon Southern Instruments Ltd., Frimley Road, Camberley, Surrey.

Spectrum Books Ltd., 6 Miletas Place, Fairhaven, Lytham St Anne's, Lancs., FY8 1BQ.

Unilab Ltd., Clarendon Road, Blackburn, Lancs., BB1 9TA.

Walden Precision Apparatus Ltd., Shire Hill, Saffron Walden, Essex.

Weir Electrical Instrument Co. Ltd., Bradford-on-Avon, Wilts.

John White and Sons, 28-30 Victoria Street, Edinburgh, EH1 2JW.

White Electrical Instrument Co. Ltd. Spring Lane North, Malvern Link, Worcs.